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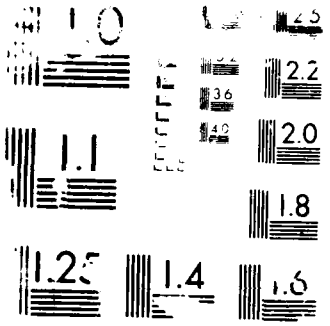
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Electron Stimulated Desorption and Coherent Electron Scattering

By

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We have studied electron-stimulated O^- desorption from O_2 condensed on thick rare-gas (Ar, Kr, or Xe) films, which were previously deposited on a Pt substrate. For ordered rare-gas layers with a fixed O_2 coverage, the O^- yield increases almost linearly as the thickness of the rare gas layer increases, particularly near the Bragg reflection energies. This is shown to arise from coherent scattering of electrons in the rare gas film.

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Electron Stimulated Desorption and Coherent Electron Scattering

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We have studied electron-stimulated O^- desorption from O_2 condensed on thick rare-gas (Ar, Kr, or Xe) films, which were previously deposited on a Pt substrate. The O_2 coverage was varied from 0.03 to 1.0 monolayers (ML) and the rare-gas (RG) layer thickness from 1 to 32 ML. The RG films can be made ordered or disordered; the ordered films show clear Bragg reflection (BR) minima in electron transmission spectra [1]. The O^- yields from the O_2/RG/Pt samples are measured as a function of the incident electron energy; these are referred to as O^- spectra. Some of the observed O^- spectra have been published previously [2,3].

Our experimental results can be summarized as follows: (1) The O^- spectra show a peak around 6 eV, analogous to the peak observed for O_2 gas [4], and additional peaks at the energies corresponding to 6 eV plus the lower RG excitation energies. (2) For ordered RG layers with a fixed O_2 coverage, the intensities of the above peaks increase almost linearly as the thickness (> 10 ML) of the RG layer increases. (3) For disordered RG layers, the spectral shapes of the 6-eV feature are the same as that for O_2 gas. (4) For ordered RG layers, on the other hand, the spectral shapes of the 6-eV feature depend on the RG, the thickness of the RG layer, and the O_2 coverage.

The experimental results described above can be explained in terms of three processes which we call the direct (D), elastic-indirect (EID), and inelastic-indirect (IID) processes. In the D process, an incident electron collides with an O_2 on the surface and produces an O^- directly. In the EID process, an incident electron at an energy below the first electronic excitation energy of the RG, passes through the O_2 layer without loss of energy, undergoes quasi-elastic multiple scattering in the RG, and returns to the surface, where it collides with an O_2 and produces O^- as in the D process. The IID process is identical to the EID, except that the electron upon initial entry into the RG film suffers loss of energy by electronically exciting the RG.

The O^- yields via the above processes are proportional to the following expressions:

$$\begin{aligned} D &\propto \theta\, \sigma(E) \\ \mathrm{EID} &\propto [1 - \theta\, \sigma_{el}(E)]\, P_r(RG,\tau,E)\, \theta\, \sigma(E), \\ \mathrm{IID} &\propto [1 - \theta\, \sigma_{el}(E)]\, P_{ex}(RG,E_{ex},E)\, P_r(RG,\tau,E-E_{ex})\, \theta\, \sigma(E-E_{ex}). \end{aligned} \qquad (1)$$

Here, E denotes the incident electron energy, θ the O_2 coverage, and $\sigma(E)$ the O^- yield cross section from an O_2 molecule on the RG film. The $[1-\theta\sigma_{el}]$ factor gives the probability of passing through the O_2 layer without loss of energy, where $\sigma_{el}(E)$ is equal to a sum of the elastic backscattering and the total inelastic cross sections of O_2. $P_r(RG,\tau,E)$ denotes the probability of the electron returning to the

surface, which depends on the RG, the RG thickness (τ), and the electron energy in the film. $P_{ex}(RG,E_{ex},E)$ denotes the electronic excitation probability of the RG film, which depends on the RG, the electronic excitation energy (E_{ex}) of RG, and the incident electron energy.

The experimental results are explained as follows: (1) The 6-eV peak arises from the D+EID processes and the 6eV-plus-RG-excitation peaks from the D+IID processes. Because of the short inelastic mean free path [5] of the electron, the total O^- yields from thick (> 10 ML) RG layers are given by D+EID for E below the first E_{ex} and D+IID for E above. (2) The intensities of the above peaks increase simultaneously as the RG layer thickness increases, because of the common factor $P_r(\tau)$ in the EID and IID contributions. $P_r(\tau)$, the returning probability, is the only factor that depends on the RG layer thickness, and it increases as the RG layer thickness increases. (3) For disordered RG layers, the spectral shapes of th 6-eV feature are the same as that for O_2 gas, because $P_r(E)$ for disordered RG films varies slowly as a function of E. It is known [6] that $\sigma_{DI}(E)$ is a slowly varying function of E. Further, $\sigma(E)$ for a thick RG layer should be similar to that for O_2 gas. Consequently, the energy dependence of D+EID, or the spectral shape of the 6-eV feature, should be similar to that for O_2 gas. (4) For ordered RG layers, the spectral shapes of the 6-eV feature depend on the RG and its thickness, because $P_r(E)$ for ordered RG films varies rapidly near the BR energies of the RG. Our analyses of the spectral shapes show that $P_r(E)$ is enhanced especially strongly near the first BR energy. The

spectral shapes also depend on the O_2 coverage, because of the $[1-\theta\sigma_{DI}(E)]$ factor.

The maximum P_r obtainable by incoherent scattering is around 2; and $P_r(E)$ due to incoherent scattering should be a slowly varying function of E. Our estimation of P_r for an ordered Ar layer with τ=32ML and E=6eV is around 90; and we find that $P_r(E)$ is a rapidly varying function of E near the first BR energy. This clearly shows that coherent scattering is playing a dominant role in O^- desorption from O_2 condensed on a thick and ordered RG film.

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References

1. G. Bader, G. Perluzzo, L.G. Caron, and L. Sanche, Phys. Rev. B 30, 78 (1984).
2. H. Sambe, D.E. Ramaker, L. Parenteau, and L. Sanche, Phys. Rev. Letters 59, 236 (1987).
3. H. Sambe, D.E. Ramaker, L. Parenteau, and L. Sanche, Phys. Rev. Letters 59, 505 (1987).
4. D. Rapp and D.D. Briglia, J. Chem. Phys. 43, 1480 (1965).
5. N. Schwentner, E.-E. Koch, and J. Jortner, "Electronic Excitations in Condensed Rare Gases" (Springer-Verlag, Berlin, 1985) Chap. 7.
6. S. Trajmar, D.F. Register, and A. Chutjian, Phys. Reports 97, 217 (1983).

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